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ABSTRACT

A study compared the effects on student achievement and retention between the problem-solving approach and the subject-matter approach in teaching a selected problem area in vocational agriculture. A quasi-experimental design, a variation of a nonequivalent control group design, was used. Treatments were randomly assigned to classes enrolled in introductory vocational agriculture courses in Illinois high schools, resulting in 66 students in the problem-solving treatment group and 60 in the subject-matter treatment group. Findings indicated that the problem-solving approach was no more or less effective as measured by student achievement, regardless of the cognitive level of the questions. It was no more or less effective in producing higher scores on the delayed retention test, regardless of the cognitive level of the questions. For the high-level cognitive items, students taught by the problem-solving approach exhibit lower achievement loss. Students' attitudes toward the problem-solving approach were slightly more positive, but the difference was not great enough to be considered statistically significant. (YLB)

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Effects of the Problem Solving Approach on Achievement, Retention, and Attitudes of High School Vocational Agriculture Students in Illinois

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Throughout the history of agricultural education, the problem solving approach has been recommended by agricultural teacher educators as the primary strategy for teaching. Several authors of agricultural education texts cite the problem solving approach as the most effective approach for teaching vocational agriculture (Binkley & Tulloch, 1981; Crunkilton & Krebs, 1982; Newcomb, McCracken, & Warmbrod, 1986; Phipps, 1980).

Some agricultural educators have questioned the effectiveness of problem solving instruction, claiming that changes in vocational agriculture programs and in student backgrounds resulting from the expansion of vocational agriculture programs beyond agricultural production have reduced the effectiveness of the problem solving approach (Moore & Moore, 1984). Others have argued that problem solving instruction results in improved learning by students (Warmbrod, 1969) and increased retention of knowledge (Binkley & Tulloch, 1981; Bruner, 1961).

Little empirical evidence exists to support the problem solving approach to teaching vocational agriculture. Studies conducted by Thompson and Tom (1957) and Dawson (1956), which compared the problem solving approach with teacher-centered instructional approaches, found some advantages in increased student achievement in favor of problem solving instruction, but were conducted prior to the expansion of vocational agriculture programs resulting from the 1963 Vocational Education Act. If agricultural educators are to continue to promote problem solving as the most effective approach to teaching vocational agriculture, there is a need to examine empirically the effectiveness of the problem solving approach in today's vocational agriculture classroom in terms of two of the most commonly accepted measures of teaching effectiveness -- student achievement and retention of knowledge.

Purpose

The purpose of this study was to compare the effects on student achievement and retention between the problem solving approach and the subject matter approach in teaching a selected problem area in vocational agriculture. The following research hypotheses provided the framework for this study:

1. Students taught by the problem solving approach will earn higher scores on a problem area achievement test administered at the conclusion of the problem area than students taught by the subject matter approach.

2. The problem solving approach will result in higher student achievement scores for low level cognitive items and high level cognitive items than the subject matter approach.

3. Students taught by the problem solving approach will earn higher scores on a problem area retention test administered one week after the achievement test than students taught by the subject matter approach.

4. The problem solving approach will result in higher student retention of information for low level and high level cognitive items on the problem area retention test than the subject matter approach.

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5. Students taught by the problem solving approach will exhibit less achievement loss, as measured by differences in scores for the achievement test and retention test, than students taught by the subject matter approach.

6. Students taught by the problem solving approach will exhibit more favorable attitudes toward the method of instruction than students taught by the subject matter approach.

Procedures

Population and Sample

The population consisted of high school students enrolled in introductory vocational agriculture courses in Illinois. A cluster sampling technique was used to select a purposive sample from the target population. Only teachers who taught two or more introductory vocational agriculture classes and had prior knowledge and experience in using the problem solving approach were considered as possible participants in this study. In order to control for overall teaching ability, the teachers taught one class using the problem solving approach and one class using the subject matter approach.

Since this study was conducted using intact groups, random assignment of students to treatments was not possible. A quasi-experimental design, a variation of nonequivalent control group design, was used for this study. Using a formula suggested by Hays (1973), which incorporated the desired alpha level, power of the test, and effect size, a necessary sample size of 60 students in each group was determined as appropriate. This sample size was based upon an alpha level of .05, a desired power of .90, and an effect size of .66 standard deviations.

Telephone interviews were conducted with 20 teachers who taught two or more introductory vocational agriculture classes to determine their knowledge and use of the problem solving approach. A list of steps involved in using the problem solving approach was used to determine if teachers were familiar with all of the steps in using problem solving instruction. Four teachers who indicated during the interviews they used all of the steps in the problem solving approach were selected and agreed to participate. Treatments were randomly assigned to the classes, resulting in 68 students in the problem solving treatment group and 61 students in the subject matter treatment group. Due to absences during the testing period, data were collected from 66 students in the problem solving treatment group and 60 students in the subject matter treatment group.

Instrumentation

An instrument to measure student attitudes toward the teaching approaches was developed by the researcher. Instruments developed by the researchers to measure the achievement and retention variables consisted of a problem area achievement test and a parallel problem area retention test. Mehrens and Lehman (1973) described parallel tests as those with equal content, constructed using the same specifications, of similar difficulty, and using the same format. Both instruments were constructed to include both high level and low level cognitive items. Content validity of the instruments was established by a panel of experts consisting of two members of the agricultural education faculty at the University of Illinois and two high school vocational agriculture teachers. The panel also evaluated the difficulty level of the items on the instruments and determined that the tests were equal in content. In addition, student scores for both instruments in the pilot test were not significantly different. The university faculty members rated each item as either a low level or a high level cognitive item using the cognitive levels described by Bloom (1956). For this study, low level cognitive items were those which required knowledge and comprehension, and high level cognitive items required application, analysis, synthesis, or evaluation.

The instruments were field tested and pilot tested for clarity and reliability using students in two vocational agriculture departments not participating in the study. The Kuder-Richardson 20 reliability coefficient for the revised student achievement instrument was .80, and a K-R 20 coefficient of .88 was calculated for the retention instrument. Reliability coefficients for the low level cognitive scale and high level cognitive scale on the achievement and retention instruments ranged from .73 to .91. Cronbach's alpha coefficient of internal consistency was .95 for the instrument measuring student attitude toward the teaching method.

Data Collection

Prior to the beginning of the study, teachers selected to participate received inservice education on the proper use of the two teaching approaches. The problem solving approach was a student-centered instructional approach, while the subject matter approach in this study was a teacher-centered approach. While the problem solving approach focused instruction on problems and concerns raised by the students, the subject matter approach focused upon agricultural subject matter selected by the teacher. With the problem solving approach emphasis was placed upon using information to develop solutions to problems, while the subject matter approach emphasized learning agricultural facts. Specific teaching techniques and learning activities to be used during the problem solution step (problem solving approach) and the presentation step (subject matter approach) were determined by the teachers.

The steps involved in the problem solving approach, as outlined by Crunkilton and Krebs (1982), included conducting an interest approach, developing student objectives for studying the problem area, identification of specific problems and concerns of students related to the problem area, developing possible solutions to problems and concerns, drawing conclusions or summarizing the appropriate solutions, and student evaluation. The steps involved in the subject matter approach included an introduction (in which the teacher presented the reasons for studying the problem area), presentation of subject matter, review of important points, and student evaluation.

Data were collected in all four schools between mid-April and early May of 1986. A problem area in corn production which required approximately 10 class periods of instructional time was selected for this study, since corn production was included in the course of study for each of the schools selected. The problem area focused upon seedbed preparation and planting procedures for corn. Each class participating in the study was visited by the researcher during the study to observe the teaching approaches used and to verify that the proper treatments were being used in the assigned groups. The problem area achievement test and attitude toward the teaching method instrument were administered immediately following the treatment, and the problem area retention test was administered one week following the achievement test. In order to control for possible preexisting group differences, average grades for the first semester of vocational agriculture and student IQ scores were collected for each student to be used as covariate measures in the study.

Analysis of Data

For the purpose of statistical analysis, appropriate null hypotheses were developed for each research hypothesis and were tested at the .05 alpha level. Multivariate analysis of covariance (MANCOVA) techniques were used to examine the data, which allowed the two dependent variables to be examined simultaneously and took into account existing correlations between the variables. Hotelling's T^2 statistic was used to determine if differences existed between the two treatment groups with univariate analysis of covariance used as a follow-up procedure. The selection of covariate

measures was supported by within group correlations computed for the covariate measures and student achievement and retention scores which indicated that the covariate measures were related to the major dependent variables. In addition, t-tests indicated significant differences between treatment groups for both average grade in vocational agriculture and student IQ, suggesting that analysis of covariance techniques were appropriate. Student attitude toward the teaching method was not assumed to be correlated with the covariate measures. Therefore, the student attitude variable was not included in the multivariate analysis of dependent variables. A t-test was used to determine if significant differences in student attitude toward the teaching method existed between the treatment groups. The data were also described using measures of central tendency, measures of variance, frequencies, and percentages.

Results

A multivariate analysis of covariance was performed on student scores for the problem area achievement test and the problem area retention test. Hotelling's T^2 statistic was .04l [F (2, l2l) = 2.50, p=.08], indicating there was no difference at the .05 alpha level between the treatment groups when student achievement and student retention were considered simultaneously. In addition, univariate follow up tests indicated no difference in student achievement or retention between the groups when cognitive levels of the items were considered. Therefore, the data did not support research hypotheses one through four.

Findings Related to Student Achievement

Student achievement was measured by the number of correct responses on the 25-item problem area achievement test. Due to pre-treatment differences between the groups, the mean scores for student achievement were adjusted using the covariate measures. Summary statistics for student performance on the problem area achievement test which included 16 low level cognitive items and 9 high level cognitive items are presented in Table l.

Table 1
Mean Student Achievement for Problem Area Achievement Test by Teaching Method

Teaching method	n	Total score		Low level items		High level items	
		Observed x	Adjusted x	Observed x	Adjusted x	Observed x	Adjusted x
Problem solving	66	13.59	13.13	9.55	9.20	4.05	3.92
Subject matter	60	13.38	13.85	9.10	9.44	4.28	4.40

Findings Related to Retention of Knowledge

Two measures of retention of acquired knowledge were used: (a) the number of correct responses on the 25-item problem area retention test and (b) achievement loss, or the difference between student scores on the achievement test and the parallel retention test. Student scores on the retention test were adjusted using the covariate measures of average grade in vocational agriculture and IQ scores. Summary statistics for student performance on the retention test are presented in Table 2.

Table 2
Mean Student Retention for Problem Area Retention Test by Teaching Methods

Teaching method	n	Total score		Low level items		High level items	
		Observed x	Adjusted x	Observed x	Adjusted x	Observed x	Adjusted x
Problem solving	66	12.24	11.89	8.02	7.75	4.23	4.14
Subject matter	60	10.90	11.25	7.27	7.53	3.63	3.73

As shown in Tables I and 2, students in the subject matter treatment group had slightly higher adjusted mean scores on the achievement test than students in the problem solving treatment group. However, the reverse was found for the retention test, with students in the problem solving group earning higher adjusted mean scores than students in the subject matter treatment group. While the differences between the groups were not significant for either achievement or retention, this reversal indicated a lower achievement loss for students in the problem solving treatment group (see Table 3)

Table 3
Mean Student Achievement Loss by Teaching Method

Teaching method	n	Total achievement loss	Achievement loss for low level items	Achievement loss for high level items
Problem solving	66	-1.24	-1.45	+0.21
Subject matter	60	-2.60	-1.91	-0.67

Note. Mean student achievement loss was calculated from mean scores adjusted for covariate measures. Negative values indicate achievement loss. Positive values indicate achievement gain.

Because of this reversal in scores, an exploratory analysis of variance was performed for achievement loss on the adjusted mean scores for the two groups to determine if the difference in achievement loss was statistically significant (see Table 4). When the total test scores were considered, there was a significant difference in achievement loss in favor of the problem solving treatment group. Research hypothesis five was supported by the data, and the hypothesis of no difference in achievement loss between students taught by the problem solving approach and students taught by the subject matter approach was rejected.

Table 4
ANCOVA Summary Table for Achievement Loss

Source of variation	SS	df	MS	F
Covariates	13.33	2	6.67	0.54
Average grade	5.62	1	5.62	0.46
IQ	1.11	1	1.11	0.09
Teaching method	54.60	1	54.60	4.40*
Residual (error)	1500.52	122	12.30	
Total	1568.44	125		

*p < .05.

In order to examine the nature of the difference in achievement loss between the two treatment groups, further analysis was performed on achievement loss for the two cognitive levels of the items. For low level cognitive items, achievement loss for the problem solving group was slightly lower, but not significantly lower, than for the subject matter group [F (l,l22) = 0.84, p = .36]. The sub-hypothesis of no difference in achievement loss for low level cognitive items was not rejected.

However, for high level cognitive items, students in the problem solving treatment group scored slightly higher on the retention test, resulting in an achievement gain, while students in the subject matter group experienced an achievement loss. An analysis of covariance was performed to determine the significance of the difference between the treatment groups. The F test indicated a significant difference between the treatment groups (see Table 5), indicating that for high level cognitive items, students taught by the problem solving approach had less achievement loss than students taught by the subject matter approach. Therefore, the data supported the sub-hypothesis associated with research hypothesis five, and the hypothesis of no difference between treatment groups for achievement loss for high level cognitive items was rejected.

Table 5
ANCOVA Summary Table for Achievement Loss for High Level Items

Source of variation	SS	df	MS	F
Covariates	5.69	2	2.85	0.82
Average grade	3.82	1	3.82	1.10
IQ	4.88	1	4.88	1.40
Teaching method	23.59	1	23.59	6.79*
Residual (error)	423.94	122	12.30	
Total	453.21	125		

*p < .01.

Findings Related to Student Attitude Toward the Teaching Method

Student attitude toward the teaching methods examined in this study was measured by student responses on the 24-item Attitude Toward Teaching Method instrument developed by the researchers. Students were asked to respond to each item on a Likert-type scale which ranged from Strongly Agree to Strongly Disagree. Responses were assigned weights ranging from one to five points. Negatively stated items were reverse scored. The maximum possible score on the attitude instrument was 120. Student scores on the attitude instrument ranged from 32 to 112. Summary statistics for student attitudes toward the teaching methods are presented in Table 6.

Table 6
Mean Scores for the Attitude Toward Teaching Method by Teaching Method

Teaching method	n	x	SD
Problem solving	66	77.14	15.86
Subject matter	60	72.45	17.29

A t-test was used to test the hypothesis of no difference in student attitudes toward the teaching approaches examined in this study. There was no significant difference in student attitude between students taught by the problem solving approach and students taught by the subject matter approach [$t_{(124)} = 1.59$, $p = .12$]. Therefore, the hypothesis of no difference was not rejected.

Conclusions

The conclusions drawn from this study were limited to the extent that the sample was not randomly selected from the population. Therefore, the conclusions are generalizable to the extent that the sample was representative of the population of students enrolled in introductory vocational agriculture courses in Illinois. Based upon the findings of this study, the following conclusions were drawn:

1. The problem solving approach is no more or less effective than the subject matter approach as measured by student achievement, regardless of the cognitive level of the questions.

2. The problem solving approach is no more or less effective than the subject matter approach in producing higher scores on the delayed retention test, regardless of the cognitive level of the questions.

3. For high level cognitive items, students taught by the problem solving approach exhibit lower achievement loss than students taught by the subject matter approach.

4. Students' attitudes toward the problem solving approach are slightly more positive than students' attitudes toward the subject matter approach, but the difference is not great enough to be considered statistically significant.

Recommendations

1. Because of the slight advantage of the problem solving approach in the area of student retention of knowledge, the problem solving approach may be used with confidence to teach introductory vocational agriculture courses.

2. Studies of similar purpose and design with a variety of problem areas and students from both rural and urban backgrounds should be conducted in vocational agriculture classrooms to increase the generalizability of the findings of this study.

3. Additional studies should be conducted to determine the effect of the problem solving approach on retention over longer periods of time.

4. Studies involving students in vocational agriculture courses should be conducted to determine the effectiveness of problem solving instruction in improving problem solving and decision making skills.

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